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Original Research Article

Aboveground Biomass Stockpile of Trees in a Sacred Grove-Tropical Dry Deciduous Forest, Dharmapuri District, Tamil Nadu, South India

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Abstract: A quantitative ecological study conducted in a sacred grove tropical dry deciduous forest in Dharmapuri district, Tamil Nadu to estimate density, species richness, basal area and aboveground biomass of trees. A one hectare (100m×100m) square plot was laid in study site. In all, 292 trees recorded in study area. Twenty four species belonging to 22 genera and 17 families were recorded from study site. This study estimated 20.18 m^2 forest tree stand's basal area. Basal area of trees varied significantly. Biomass stockpile varied considerably among species in study area. In all, 184842.51 kg ha^{-1} (=184.842 tonne) aboveground biomass recorded from study site. Conservation of this kind of forest i.e., sacred grove is essential to protect indigenous species from extinction.
Keywords: aboveground biomass; south India; tropical forest; tropical trees.

INTRODUCTION

Tropical forests are the largest sink of carbon in the world [1] and it lodges ~212 Gt of carbon in its vegetation [2]. Half of all terrestrial C which account for about 80% of C exchange between terrestrial ecosystem and the atmosphere is present in the forests globally. It has been estimated that the forest ecosystems absorb up to 3 billion tons of C annually. Conservation of C in forest ecosystem is regarded as a good practice and it has the greatest potential for slowing the rate of climate change [3].

Forest type of the study area is known as tropical dry deciduous forest (TDDF). Many of the TDDFs are highly fragmented and invariably protected as 'sacred groves' (SGs). Sacred groves are culturally important natural forests and having inseparable link with rural people, support the life of many indigenous and important flora and fauna [4-7]. As to our knowledge, information on aboveground biomass stockpile of tropical dry deciduous forest is very limited thus, this study was conducted to fill the above said gap.

MATERIALS AND METHODS

Study area

This study conducted in a sacred grove tropical dry deciduous forest situated at Puliyambatti village of Harur taluk in Dharmapuri district. The district is located between latitudes N 11 47' and 12 33' and longitudes E 77 02' and 78 40'. Occupies an area of 4497.77 km² (i.e. 3.46% of Tamil Nadu state) and has a population of 2,856,300 (as of 2001). It is bounded on the north by Krishnagiri District, on the east by Tiruvannamalai District and Viluppuram District districts, on the south by Salem District, and on the west by Karnataka's Chamarajanagar District. The entire district is surrounded by hills and forests. This district endowed with rich biodiversity especially hills of Chitheri and Theerthamalai having rich tree diversity.

Field survey

A one hectare (100m×100m) square plot was laid in study site. The 1-ha area divided in to a hundred 10m×10m workable sub-plots. All trees ≥5cm diameter at breast height (gbh; 137 cm from the ground) was measured. The quantitative forest survey conducted during April-December, 2012 to reveal tree density, richness, diversity, dominance etc. For multi-stemmed trees, the girth of individual stem was measured separately, basal area calculated and summed-up. All recorded trees identified to species level with the help of regional floras.

Biomass estimation

Dry biomass of trees estimated with the following formula. Dry aboveground biomass of tree (kg) = WD×exp (-0.667+1.784×LN (DBH) +0.207× (LN (DBH)) ^{2}-0.0281× (LN (DBH)) ^{3}) [1]. Where: WD=Wood density; exp = e to the power of; LN=Natural logarithm; DBH=Diameter at breast height; -0.667, 1.784, 0.207,-0.0281 are constants. The authors obtained this equation using a large dataset of trees ≥ 5 cm dbh, directly harvested in 27 study sites across the tropics. This formula is applicable to trees with 5-156

cm DBH and not applicable to palms. Hence, we too followed the same equation and considered all the trees (≥ 5cm dbh or ≥16 cm gbh) for the estimation of AGB.

RESULTS

Density

In all, 292 trees recorded in study area. Density of individual species' varied considerably. Density of species ranged from just one to forty in study area. *Holoptelea integrifolia* (Ulmaceae) represented by 41 trees followed by *Azadirachta indica* (30 trees) and *Cassine glauca* (29), while *Ailanthus excelsa* (Meliaceae) and *Annona reticulata* (Annonaceae) were represented by just single individual in study area.

Species richness

Twenty four species belonging to 22 genera and 17 families were recorded from study site. The family Mimosaceae represented by three species followed by Annonaceae, Rubiaceae, Papilionaceae, Moraceae and Meliaceae each represented by two species, while remaining families had single species' each in study area (Table 1).

Table-1: Binomial and family of trees recorded in study area

Binomial	Family
Acacia nilotica (L.) Willd.	Mimosaceae
Ailanthus excelsa Roxb.	Meliaceae
Alangium salvifolium (L.f.) Wang.	Alangiaceae
Albizia amara (Roxb.) Boivin	Mimosaceae
Annona reticulata L.	Annonaceae
Annona squamosa L.	Annonaceae
Azadirachta indica A. Juss.	Meliaceae
Butea monosperma (Lam.) Taub.	Papilionaceae
Canthium coromandelicum (Burm. F.) Alston	Rubiaceae
Cassine glauca (Rottb.) Kuntze	Celastraceae
Crateva magna (Lour.) DC.	Capparidaceae
Diospyros ebenum Koen.	Ebenaceae
Ficus benghalensis L.	Moraceae
Ficus religiosa L.	Moraceae
Holoptelea integrifolia (Roxb.) Planch.	Ulmaceae
Morinda pubescens J.E. Smith	Rubiaceae
Pisonia aculeata L.	Nyctaginaceae
Pongamia pinnata (L.) Pierre	Papilionaceae
Prosopis juliflora (Sw.) Dc.	Mimosaceae
Streblus asper Lour.	Moraceae
Strychnos nux-vomica L.	Loganiaceae
Tamarindus indica L.	Caesalpiniaceae
Wrightia tinctoria (Roxb.) R.Br.	Apocynaceae
Ziziphus mauritiana Lam.	Rhamnaceae

Forest stands' basal area

This study estimated 20.18 m^2 forest tree stand's basal area. Basal area of trees varied significantly. *Tamarindus indica* recorded highest BA 4.96 m^2 ha^{-1} followed by *Albizia amara* 3.78 m^2 ha^{-1}, Ficus religiosa 3.59 m^2 ha^{-1}, while *Annona reticulata* recorded the least BA i.e., 0.004 m^2 ha^{-1}in study area. Just with 10 individuals *Tamarindus indica* recorded the highest BA. Though represented by large number of trees *Holoptelea integrifolia* (41), *Azadirachta indica* (39), *Cassine glauca* (30) recorded the moderate BA in study site (Table 2).

Biomass of trees

In all, 184842.51 kg ha^{-1} (=184.842 tonne) aboveground biomass recorded from study site. Biomass stockpile varied considerably among species in study area. *Tamarindus indica* stocked the highest biomass 59900.63 kg ha^{-1} followed by *Albizia amara* 40418.96 kg ha^{-1}, *Holoptelea integrifolia* 18846.50 kg ha^{-1} while Prosopis juliflora (7.17 kg ha^{-1}), *Annona reticulata* (14.58 kg ha^{-1}) and Canthium coromandelicum (21.16 kg ha^{-1}) stocked the least biomass in study area (Table 3).

Table 2: Binomial and basal area of trees found in study area

Binomial	**Basal area (m^2 ha^{-1})**
Acacia nilotica (L.) Willd.	0.070
Ailanthus excelsa Roxb.	0.029
Alangium salvifolium (L.f.) Wang.	0.307
Albizia amara (Roxb.) Boivin	3.777
Annona reticulata L.	0.004
Annona squamosa L.	0.048
Azadirachta indica A. Juss.	0.816
Butea monosperma (Lam.) Taub.	0.320
Canthium coromandelicum (Burm. F.) Alston	0.005
Cassine glauca (Rottb.) Kuntze	0.347
Crateva magna (Lour.) DC.	0.052
Diospyros ebenum Koen.	1.186
Ficus benghalensis L.	1.861
Ficus religiosa L.	3.588
Holoptelea integrifolia (Roxb.) Planch.	1.725
Morinda pubescens J.E. Smith	0.071
Pisonia aculeata L.	0.045
Pongamia pinnata (L.) Pierre	0.190
Prosopis juliflora (Sw.) Dc.	0.002
Streblus asper Lour.	0.059
Strychnos nux-vomica L.	0.120
Tamarindus indica L.	4.955
Wrightia tinctoria (Roxb.) R.Br.	0.206
Ziziphus mauritiana Lam.	0.046
Total	**20.183**

Table 3: Binomial, density, aboveground biomass of trees recorded in study area

Binomial	**Density**	**Biomass (kg)**	**% contribution to site biomass**
Acacia nilotica (L.) Willd.	4	548.59	0.297
Ailanthus excelsa Roxb.	1	116.72	0.063
Alangium salvifolium (L.f.) Wang.	14	3604.60	1.950
Albizia amara (Roxb.) Boivin	28	40418.96	21.867
Annona reticulata L.	1	14.58	0.008
Annona squamosa L.	15	206.20	0.112
Azadirachta indica A. Juss.	39	7532.19	4.075
Butea monosperma (Lam.) Taub.	6	2980.06	1.612
Canthium coromandelicum (Burm. F.) Alston	4	21.16	0.011
Cassine glauca (Rottb.) Kuntze	30	2177.70	1.178
Crateva magna (Lour.) DC.	2	176.59	0.096
Diospyros ebenum Koen.	16	10772.18	5.828
Ficus benghalensis L.	5	13356.12	7.226
Ficus religiosa L.	2	17646.75	9.547
Holoptelea integrifolia (Roxb.) Planch.	41	18846.50	10.196
Morinda pubescens J.E. Smith	9	305.72	0.165
Pisonia aculeata L.	8	159.09	0.086
Pongamia pinnata (L.) Pierre	11	1272.37	0.688
Prosopis juliflora (Sw.) Dc.	2	7.17	0.004
Streblus asper Lour.	20	318.55	0.172
Strychnos nux-vomica L.	4	1415.28	0.766
Tamarindus indica L.	10	59900.63	32.406
Wrightia tinctoria (Roxb.) R.Br.	12	2729.79	1.477
Ziziphus mauritiana Lam.	8	315.02	0.170
Total	**292**	**184842.51**	**100.00**

DISCUSSION

Density

Tree density recorded in this study (292 trees ha^{-1}) is comparable with other tropical forests such as tropical dry forests of Chattishgarh (216-292 trees ha^{-1}) [8], dry deciduous forests of Mudumalai (348 trees ha^{-1}) [9], tropical dry forests of Vindhyan hills (35-419 trees ha^{-1}) [10]. Density of trees is also higher than what has been reported for tropical dry deciduous forests of Western Ghats (243 trees ha^{-1}) [11]. However, density of trees recorded from present study is lower than tropical dry forests of Rajasthan (995 trees ha^{-1}) [12], dry deciduous forests of Bandipur hills (905 trees ha^{-1}) [13], tropical dry deciduous forests of Karnataka (883 trees ha^{-1}) [14], tropical forests of dry deciduous forests of Andhra Pradesh (563-1018 trees ha^{-1}) [15], tropical dry deciduous forests of Madhya Pradesh (690-2500 trees ha^{-1}) [16], and tropical deciduous forests of Mexico (804-2117 trees ha^{-1}) [17].

Species richness

Species richness of trees recorded in this study (24 species ha^{-1}) is comparable with other tropical forests such as tropical dry evergreen forests (20-36 species [18]); tropical dry deciduous forests of Udaipur (18-38 species ha^{-1}) [9]. Species richness of trees is also higher than in tropical forests of Chattishgarh (5-9 species ha^{-1}) [8], tropical dry forests of Vindhyan hills (4-23 species ha^{-1}) [19], tropical dry deciduous forests of Madhya Pradesh (2-14 species ha^{-1}) [21] and dry deciduous forests of Mandla (12-14 species ha^{-1}) [20]. On the other hand, species richness of trees recorded in study area is lower than in tropical semi evergreen forests of Western and Eastern Ghats (30-90 species).

Stand basal area

Forest tree stands' basal area recorded in this study (20.18 m^2 ha^{-1}) is higher than in tropical forests such as in tropical dry forests of Chattishgarh (4.99-7.34 m^2 ha^{-1}) [8], tropical dry forests of Vindhyan hills (1.30-13.78 m^2 ha^{-1}) [10], tropical dry evergreen forest of Villupuram (4.31 m^2 ha^{-1}) [17] and deciduous forests of BR hills (7.9 m^2 ha^{-1}) [21]. Conversely, Stand basal area of trees recorded in this study is lower than in tropical dry deciduous forests of Madhya Pradesh (93.93-155.48 m^2 ha^{-1}) [14], dry deciduous forests of Mudumalai (22.3 m^2 ha^{-1}) [13], deciduous forests of Andaman (49.4-57.5 m^2 ha^{-1}) [22] and, tropical dry forests of Rajasthan (46.35 m^2 ha^{-1}) [12].

Aboveground biomass stockpile

Tree biomass estimated in this study (184.84 Mg ha^{-1}) is higher than in Asian natural forests (70 tonne ha^{-1}; [5], dry deciduous forest (70.55- 77.9 tonne ha^{-1}; [24]), tropical dry evergreen forests of Cuddalore, Villupuram and Pudukottai (102.14 tonne ha^{-1}; [5]) and tropical forest of Pachaimalai (50.6 tonne ha^{-1}; [25]). On the contrary, biomass of trees recorded in this study is lower than in tropical forests of wet (759.9 tonne ha^{-1}) and giant evergreen forests of Andaman (332.40-353 tonne ha^{-1}; [26]), Asia's undisturbed closed forests (214.66 tonne ha^{-1}; [27]), rain forests of India (420-649 tonne ha^{-1}; [28]) and moist evergreen (400.2- 465.4 tonne ha^{-1}; [29]). In general, density, species richness, wood density of trees, and type of forest, elevation of forest ite, species composition and other environmental factors plays major role in AGB stockpile of trees in forests [18].

CONCLUSION

Density, species richness, stands' basal area and biomass of trees recorded in this study are equal, higher and lesser compared to tropical forests in India and forests elsewhere. Study area has moderate density and species richness. This study concentrated only on trees in a hectare area, studies of this kind with larger study areas is essential to estimate the actual density aboveground dry biomass of trees in tropical dry deciduous forests in Tamil Nadu.

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